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(71) Applicant *(for all designated States except US)*: ASEA BROWN BOVERI AB [SE/SE]; S-721 83 Västerås (SE).

(72) Inventors; and
(75) Inventors/Applicants *(for US only)*: BIJLENGA, Maria [SE/SE]; Åkestavägen 7, S-730 50 Skultuna (SE). JEPPSSON, Ola [SE/SE]; Dybecksgatan 10C, S-722 22 Västerås (SE). LILJESTRAND, Lars [SE/SE]; Björnramsvägen 12, S-722 42 Västerås (SE).

(74) Agents: ZILLING, Staffan et al.; Dr. Ludwig Brann Patentbyrå AB, P.O. Box 171 92, S-104 62 Stockholm (SE).

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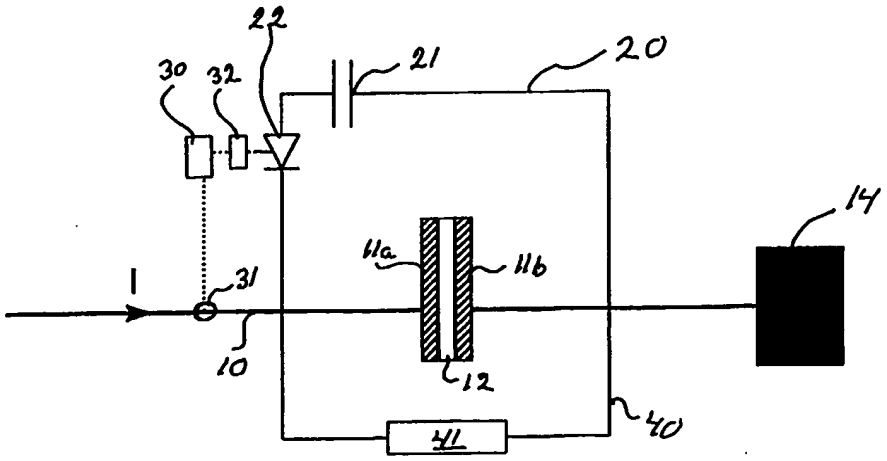

(57) Abstract

A device for current limitation and protection against faults in the load current fed to an electrical load, in the form of an electrical apparatus or installation, a fault current limiter. The fault current limiter is electrically connected in series with the load to be protected in a main circuit for power supply of the load. The current limiting element is electrically connected to a circuit for current injection. The circuit for current injection comprises a capacitor connected in series with a switch. A control unit with sensors for monitoring the load current in the main circuit and control means are arranged to control and operate the switch in the circuit for current injection based on changes in the properties of the load current in the main circuit, such that upon detection of a fault the capacitor is discharged through the current limiting element.

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A DEVICE FOR CURRENT LIMITATION AND PROTECTION AGAINST FAULTS IN A CURRENT

TECHNICAL AREA

The present invention relates to a device for current limitation and protection against faults in a current fed to an electrical load, in the form of an electrical apparatus or installation. The device is designated a fault current limiter and comprises an electrically conductive current limiting element.

BACKGROUND ART

A device of the above mentioned kind is for example a fuse comprising an element which upon overload or a large over-current, a fault, will trip, i.e. melt, when the faulty current has caused a sufficiently large energy development in the current limiting element to bring the fuse-element to a temperature above its melting point. This device exhibit an energy controlled trip with little sensitivity as to the nature of the fault.

European patent document EP 0 487 920 discloses a device for current limitation and protection against overload and shortcircuit currents which comprises a current-limiting element based on a so called PTC-element. The PTC-element disclosed in this document comprises a polymer-based electrically conductive body that exhibits a resistivity with positive temperature coefficient and at least two electrodes, where the polymer-based body is in free contact with at least one of the electrodes or an other electrically conductive body. The expression, in free contact, means in this application that the body is not bonded to an electrode by welding, soldering, adhesives, fusion or any other chemical or physical bond but that the electrode and body is held together and electrical contact is maintained over such contact surface by a compressive force applied by pressure-applying means to hold the electrode against this contact surface of the body. This will give rise to a contact pressure between body and electrode in such a contact surface. Since current transition over such surface only occur in a number of contact points, a current constriction arises at the surface, which result in a voltage drop. This

voltage drop will be located substantially in a layer of the body which exhibits the highest resistivity, i.e. the polymer based body.

At currents below rated current, a low contact resistance is maintained at the contact surface in that the pressure-applying means applies a sufficient pressure to ensure current transition in a sufficient large number of contact points. At short-circuit currents the temperature will increase at the contact points resulting in a local melting and/or gasification of the polymeric material at some of these contact points. Eventually, a layer of gasified polymer/carbon will develop in the vicinity of this contact surface, whereby the resistance is increased sharply and markedly across this layer and the current through the PTC-element is limited, the PTC-element trips. This increase in resistance will limit the current passing through the PTC-element. Since the contact pressure is maintained by the pressure-applying means the original contact resistance is essentially resumed across the polymer based body and electrodes as the current is limited and the gas pressure decreases. The sharp change in resistance when the PTC-element switches from low-resistivity to high-resistivity state and vice-versa at gasification and restoration respectively is for a material such as polyethylene with a carbon black filler in the order of from a tenths of a mΩ or less to hundreds of mΩ or more.

The international application WO-96/25783 discloses a current limiter for which it is possible to control at which electrode tripping will occur and thereby offer a faster and more reliable current limitation at short-circuit currents or other fault currents. This current limiter comprises a polymer based electrically conductive body with two contact surfaces, where one of the contact surfaces is contacted, i.e. the voltage drop at this contact surface and its corresponding electrode is minimised while the other contact surface of the body is in free contact with its electrode. This is achieved by arranging the body with a surface layer, which exhibits a lower resitivity than the bulk of the body, at the contacted contact surface. A contacted surface of this kind comprising a surface layer with lower resistivity than the bulk of the body is in this application designated, a contacted contact surface.

The current limiters described are all energy controlled, i.e. they will trip after the fault current have caused a sufficient energy development in the current limiting element mainly concen-

trated to the surface(s). This suits applications operating at a low rated current, i.e. a current below 63 A, but such energy controlled current limiters cannot be directly used for applications operating with rated current of 63 A or higher, such as in apparatuses and installations for generation, transmission and sub-transmission of electrical energy as;

a, the difference between the rated current and limited fault currents are small;

b, the high rated current will require contact surfaces with large active contact areas, which will decrease the current density at short-circuit currents in this contact surface and thus increase the amount of energy let through the current limiter before trip, at short circuit currents;

c, a low resistance is required over the polymer based body and connected electrodes to minimise heat development and losses at currents below the high rated load current, the low losses at or below rated currents will thus be achieved at the cost of an increase in the let through energy before trip, i.e. longer times to trip and increased risks for damages;

d, it will not be possible to set precise trip current levels as the trip is controlled by the let through energy; and

e, when used for higher voltages it will be necessary to connect a plurality of current limiting elements in series, this will for energy controlled current limiting elements require simultaneous tripping.

It is therefore the objective of the present invention to offer a Fault Current Limiter with a current limitation or trip controlled by the occurrence of a fault in the load current and not by the let through energy which is caused by the fault current.

It is further the objective of the present invention to offer current limiting elements;

I, that will trip essentially simultaneous irrespective if they are connected in series or in parallel to accommodate higher voltages or currents respectively;

ii; that will trip fast on occurrence of a fault in the load current irrespective of which property in the load current that is faulty, e.g. its magnitude, its time derivative, (di/dt); and

iii, offer the ability to precisely predict and assure at which type or value of a fault in the load current the fault current limiter is caused to trip. Suitable algorithm for analysing a disturbance in the current properties and detect what is deemed to be a fault is known.

SUMMARY OF THE INVENTION

A device for current limitation and protection against faults in a current fed to an electrical load, e.g. a load in the form of an electrical apparatus or installation to be protected, is in this application called a fault current limiter. A fault current limiter according to the present invention comprises an energy controlled current limiting element in the form of an electrically conductive body such as a PTC-element or a fuse, electrically connected in series with the load. To accomplish the objects defined in the foregoing a circuit for current injection is electrically connected with the current limiter. The current supplied to the load through the fault current limiter is in this application called the load current and its current path the main circuit. The circuit for current injection comprises according to the present invention a capacitor and a switch connected in series.

The switch, which can be either a mechanical switch or a switch based on a power semiconductor such as a thyristor, is controlled and operated by a control unit based on changes in the properties of the load current.

The charge of the capacitor is sufficient to upon release cause the current limiter to trip on its own or in combination with the fault current cause an energy development in the current limiting element exceeding trip energy.

The control unit which is arranged to control and operate the switch comprises;
- a sensor that monitors the properties of the load current;
- a processor that analyses the properties of the monitored load current and on detection of certain deviations in these properties activates means which operates the switch. These means operating the switch can be electromechanical means or an out signal generated in the processor which when received by the switch activates the switch or thyristor

When the electrical load installation is in operation and the load current supplied exhibit properties within acceptable ranges the capacitor is pre-charged and the load current flows through the current limiting element which is connected in series with the load in the main circuit.

The resistance over the current limiting element in the form of a PTC-element is minimised as described in the foregoing and in accordance with EP 0 487 920 or WO-96/25783. Such a current limiting element comprises;

- a polymer-based electrically conducting body electrically connected to the current injection circuit,
- at least one electrode held in free contact with a contact surface of the body; and

that this body comprises at least one trip zone adjacent to the electrode held in free contact and that upon injection of a sufficiently high current gas is evolved in the trip zone resulting in a essentially reversible change from low-resitivity state to high-resistivity state of the current limiting element. Any fault in the current, detected by the control unit, will result in the current injection circuit being closed and the capacitor being discharged. The discharge of the capacitor will cause an injection of a sufficiently amount of energy into the current limiting element causing the limiter to trip, e.g. by gas evolution in the parts of the polymer based body which constitutes trip zone(s). The fault can be a rise in magnitude, a change in the time derivative of the current or any other change in a property deemed to be harmful for the load and which the control unit is arranged to react upon.

A similar situation will occur in a fault current limiter where the current limiting element described in the foregoing is replaced by another energy controlled trip means such as a melt fuse or a bulk PTC-element. The discharge of the capacitor will cause a sufficient energy development in the fuse to cause it to melt and the limiter to trip or in the case of the bulk PTC-element cause it to reach a temperature exceeding its trip temperature. Thus this basic principle with a fault current limiter comprising an energy controlled current limiting element electrically connected to a current injection circuit as defined in the foregoing will be applicable for any type of energy controlled current limiting element.

For a current limiter of the type based on a current limiting element as disclosed in WO-96/25783, i.e. comprising a contacted surface and a surface in free contact with its electrode, the trip zone of the polymer based body is predetermined to a thin layer adjacent to the electrode in free contact, the tripping side, while the electrode and the body on the contacted side, the non-tripping side, as well as the bulk of the body remains essentially unaffected by the trip,

i.e. the body exhibits a tripping side and a non-tripping side. A substantial part of the energy developed in the body is developed in the trip zone, and essentially all localised heating and gasification in other areas of the body is avoided due to the low energy development at the contacted surface of the body and the similarly low energy development in the bulk of the body. As a result of this the gas evolution in the trip zone will give an even current limitation effect over the whole contact surface on the tripping side. The gas produced by the polymer and the filler due to energy development in the trip zone will be sufficient to separate the whole electrode on the trip side from the body.

According to preferred embodiment of the fault current limiter the current limitingelement comprises a divided electrode on one side of the polymer-based body. At least one part of the divided electrode is connected to the main circuit and at least one part of the divided electrode is connected to the current injection circuit. The use of a divided electrode allows for a reduction in the current injection energy while still achieving the same current limiting effect. The gas generated in a tripping zone in the part of the body comprising a contact surface in contact with the current injection part-electrode will spread over the whole contact surface on the tripping side, separating the whole electrode on the tripping side from the body.. The divided electrode can be either contacted to its contact surfaces on the polymer body or held in free contact with these surfaces. The use of a divided electrode on one side of the body results in that the current injection energy, i.e. the energy released when the capacitor is discharged upon detection of a fault in the load current can be reduced so can also the size of the capacitor and the switch.

According to one embodiment the divided electrode is contacted with its contact surfaces on the non-tripping side and one large electrode is held in free contact with the contact surface on the other side, the tripping side. But provided that the divided electrode is supported by a mechanically stiff supporting plate the divided electrode can be arranged on the tripping side. The supported and divided electrode will then be held in free contact with its contact surfaces while the one large electrode on the other side can be either contacted or held in free contact. The supporting plate need to be electrically insulating so that the parts of the divided electrode is electrically isolated from each other.

In one further embodiment of the fault current limiter the current limiting element in addition to the divided electrode also exhibits a division of the electrically conductive body arranged so that one first body is connected to the circuit for current injection, that one second body is connected to the main circuit. Preferably is a electrically insulating body or a layer sandwiched between the first and second body. According to one embodiment the electrically conducting bodies are on one side of the fault current limiter connected to two separate electrodes, one for the main circuit and one for the current injection circuit, while on the other side a common electrode is used. The common electrode is preferably held in free contact with its contact surfaces on both bodies. But provided that a divided electrode is supported by a mechanically stiff and electrically insulating supporting plate also the supported and divided electrode can be held in free contact with its contact surfaces on the bodies. Thus can in a further alternative embodiment an divided electrode be used on both sides.

The first body, which is included in the current injection circuit, is preferably a polymer-based body as described in the forgoing while a body exhibiting an equal or lower resistivity is favourably chosen for as the second body, i.e. the body in the main circuit. The possibility to use a body with a lower resistivity for the main circuit offers a possibility for reduction in losses at normal operation conditions at or below rated current. Such an improvement will not be offset by any delay in response to a detected fault as the capacitor still will be discharged into the current injection circuit comprising the current limiting element. The gas evolved from the trip-zone in the polymer based body has proven sufficient also to separate a common electrode or a supported divided electrode on the trip side from the body in the main circuit. Suitable material for such a body included in the main circuit is graphite, polymer-based composites with equal or a higher carbon content or a metal, metal composite, ceramic or ceramic composite and thus an equal or lower resistivity than the first body.

According to one alternative embodiment electromechanical means is arranged electrically in series with a current injection circuit. These means are adopted to upon discharge of the capacitor through them generate a mechanical force. The generated mechanical force will counteract a contact pressure applied over electrodes and a polymer based body by pressure applying means. The fault current limiter used for this embodiment comprises;

- electrodes;
- an electrically conducting polymer based current body with at least one contact-surface in free contact with an electrode; and
- pressure-applying mechanical means such as springs or other resilient element to apply an elastic force that holds the electrodes and polymer based body together and applies a contact pressure in the contact surfaces. The electromechanical means will on occurrence of a fault in the load current the capacitor is discharged through them and a mechanical force that counteracts and reduces the pressure applied on contact surfaces is generated by the electromechanical means. As the contact pressure thus is reduced on discharge of the capacitor in the current injection circuit the contact resistance in a surface where the polymer based body is in free contact with its electrode is increased and tripping is initiated at such a side. Preferably one side is made the tripping side by arranging one side in free contact with its electrode and the other side contacted but both sides can be held in free contact with respective electrode. Suitable electromechanical means are flat coils with opposite winding directions, connected in series with each other and the current injection circuit, arranged within pressure-applying means, preferably within a rigid mechanical framework included in these means to ensure that the applied mechanical force is evenly distributed over the whole contact surface. One coil can be replaced with a conducting surface acting like a short-circuit winding.

The electromechanical means as described in the foregoing and the principle of current injection can be combined in different way to increase the sensitivity of the fault current limiter.

In one embodiments the mechanical means are connected in series with the current injection circuit which is electrically connected to the current limiting element. Alternatively both the electromechanical means and the polymer based current limiting element are electrically connected to the current injection circuit. Of course can also a plurality of current injection circuits be arranged and connected so that at least one is connected to the current limiting element and one or more to the electromechanical means.

By employing fault current limiters according to the present invention which is caused to trip based on a fault in the main load current by a control unit using a current injection circuit

comprising a capacitor and a switch operated by the same control unit there is no problem to assure simultaneous tripping of a plurality of fault current limiters which are included in the same main circuit and electrically connected,

- in parallel to increase current capability, i.e. allow higher rated currents or
- in series to allow higher rated voltages, or
- by connecting a plurality of groups, each group comprising a plurality of current limiting element electrically connected in parallel, electrically in series to simultaneously increase both the voltage and current capabilities,

as the current injection in all fault current limiters will be triggered by the same fault. It will even be possible and suitable to use the same control unit to trig and operate all switches thus connected.

DESCRIPTION OF THE DRAWINGS

Fault current limiters according to preferred embodiments of the present invention are illustrated further in the following description by way of examples and while referring to the drawings.

Figure 1 is a schematic sketch showing the main circuit and the current injection circuit according to one embodiment of the invented fault current limiter.

Figure 2 is a schematic sketch of an embodiment with a divided electrode on one side of the polymer based body.

Figure 3 is a schematic sketch of an embodiment with a divided electrode on one side and a divided body comprising the polymer based body in the current injection circuit and second electrically conductive body in the main circuit.

Figure 4 is a schematic sketch of an embodiment with a divided electrode on both sides and a divided body comprising of the polymer based body in the current injection circuit and second electrically conductive body in the main circuit.

DESCRIPTION OF THE PREFERRED EMBODIEMENTS

The fault current limiter according to embodiment illustrated in figure one is installed in the main power supply line 10 feeding a load current to a load 14 in the form of one or a multiple of electrical apparatuses or installation. The load 14 can be any kind of electrical installation from a single electrical device to a network. To protect the load 14 from faulty currents and to limit such currents in a current limiting element in the form of an electrically conductive polymer based body 12 with two electrodes 11a, 11b is connected in series with the load 14. The faulty current can be a short-circuit current, a lasting overload current but also a disturbance in the time derivative of the current or any other disturbance of the properties deemed to be a fault. The electrode 11a on one side, e.g. the side facing away from the load as shown in the figure is preferably contacted, i.e. its surface has been prepared such that the resistance over the electrode and contact surface is reduced compared to an untreated contact surface, while the conductive polymer based body in the current limiter shown in figure 1 is on the load side held in free contact with its electrode 11b. Thus will the side of the current limiting element facing the load 14 constitute the tripping side and the side facing away from the load 14 will constitute the non-tripping side. It is, however not necessary that the load side is the tripping side but the contacted electrode and the electrode held in free contact can be switched around or both electrodes can be held in free contact with its contact surface.

According to the present invention a circuit for current injection 20 is electrically connected with the current limiting element in the main circuit 10. This circuit for current injection comprises a capacitor 21 with a charge of a size sufficient to cause the current limiter to trip upon discharge, and a switch, preferably a thyristor 22 connected in series with the capacitor. The current limiter is also equipped with a control unit 30 operating the switch 22 so that on detection of a disturbance in the current deemed to be a fault the circuit 20 for current injection is closed and the capacitor 21 is discharged. The energy released upon discharge of the capacitor 21 results in a current being injected through the body 12 that is sufficient to cause the current limiter to trip and only a limited current will pass through the resistor 41 provided in a second circuit 40 in parallel with the current limiting element. The discharge can be sufficient to cause the limiter to trip on its own or in combination with the faulty current.

The control unit have a sensor 31 for monitoring the load current in the main circuit. Such a sensor might be a current transformer linked to suitable instruments for analysing the current as to magnitude, time derivative and other critical properties. Suitable algorithms for use in the control unit is known. On detection of certain deviations in these properties control means 32 in the control unit 30 will operate the switch as described in the foregoing to discharge the capacitor 21. The control means 32 can be an out-signal from the control unit 30 to the switch 22 or a motor operating a mechanical switch or the thyristor. With a fault current limiter as shown in figure 1 arranged for current injection has shown it possible to reduce the main circuit let through energy in the polymer based body before trip by 10 times or more in comparison to the same current limiter without current injection. As the current injection is controlled by the control unit 30 is it possible to set exact conditions for tripping and also to ensure simultaneous tripping of several current limiting elements connected in series or parallel to raise the capability for higher voltages or load currents respectively of the fault current limiter.

A fault current limiter according to the embodiment as shown in figure 2 exhibit a further reduction of the required energy for trip. This further reduction have been accomplished by dividing the electrode on at least one side of the body 12. The current limiting element shown in figure 2 has the divided electrode arranged on the side facing away from the load but a divided electrode can be arranged on either side or on both sides of the body provided that the divided electrode when held in free contact with the polymer body on a tripping side is supported by a mechanically stiff supporting plate, not shown. A supporting plate for a divided electrode need to be in an electrically insulating material such that the two part electrodes 110,111 are electrically insulated from each other.

With a fault current limiter according to the embodiment shown in figure 3 has the losses in the current limiting element at normal operating conditions at or below rated current been substantially reduced. This has been accomplished by also dividing the body in two. The two part-bodies are connected at one side by a common electrode 112 and on the other side by the divided electrode, exhibiting one part electrode 111 for the current injection circuit and one part electrode for the main circuit 110. The conductive body 120 used for the main circuit 10 have

a resistivity equal to or lower than the resistivity exhibited by the polymer based current limiting element 121 in its low-resistivity state. Suitable materials for the second body to be used in the main circuit is a polymer-based composite with a similar carbon content or a higher carbon content, preferably the same type of carbon is used. Also other conductive or semiconductive materials, e.g. metals, ceramic based materials or a graphite based disc or felt can be used. The fault current limiter shown in figure 3 has a third electrically insulating body 122 or a layer sandwiched between the two bodies 121 and 120 respectively. The part electrodes 110,111 comprised in the divided electrode is in one suggested embodiment arranged contacted while the common electrode 112 on the other side is held in free contact with its contact surfaces on the two bodies 120,121 but also the divided electrode can be held in free contact. Thus allowing for further alternative electrode configurations, e.g. that the divided electrode is held in free contact while the common electrode 122 is contacted or both the divided electrode and the common electrode 122 can be held in free contact. As already described for the embodiment shown in figure 2 a divided electrode can be held in free contact with the polymer body provided that it is supported by a mechanically stiff supporting plate, not shown. A supporting plate for a divided electrode need to be in an electrically insulating material such that the two part electrodes 110,111 are electrically insulated from each other.

In figure 4 a divide electrode is arranged on both side of the body, which is arranged comprising a divided electrically conductive body 120,121 as already described for the embodiment shown in figure 3. The part electrodes 110,111,115,116 of either of the divided electrodes is preferably contacted to its contact surfaces while the other divided electrode is supported with a supporting plate, not shown, and arranged such that its part electrodes 110,111,115,116 are held in free contacts with its contact surfaces. Alternative both the divided electrodes are provided with a supporting plate and arranged such that its part electrodes 110,111,115,116 are held in free contact with the contact surfaces of the bodies 120,121.

CLAIMS

1. A device for current limitation and protection against faults in a current fed to an electrical load (14), in the form of an electrical apparatus or installation, a fault current limiter, comprising a current limiting element electrically connected in series with the load to be protected in a main circuit and electrically connected to a circuit for current injection (20) comprising a capacitor (21) connected in series with a switch (22), **characterised** in that the circuit for current injection comprises a control unit (30) with
- sensor means (31) arranged to monitor the current in the main circuit; and
- control means (32) arranged to analyse the properties of the monitored current and based on this analysis control and operate the switch in the circuit for current injection, such that upon detection of a disturbance deemed to be a fault the capacitor is discharged through the current limiting element causing it to trip.

2. A fault current limiter according to claim 1, **characterised** in that the capacitor (21) in the current injection circuit is pre-charged with an energy that upon discharge releases sufficient energy to cause the current limiter to trip.

3. A fault current limiter according to any of claims 1 or 2, **characterised** in that current limiting element comprises;
- one or more electrically conducting bodies (12; 120, 121)each arranged with two contact surfaces;
- electrodes (11a 11b; 110, 111, 112, 115, 116)
- pressure applying means to hold the electrodes and body/bodies together and apply a sufficient contact pressure in the contact surfaces to ensure low contact resistance at currents at or below rated current and means to increase the resistance over the element substantially when the current injection capacitor is discharged through said means for increasing the resistance upon detection of a fault in the monitored current.

4. A fault current limiter according to claim 3, **characterised** in that the current limiting element comprises;

- a polymer-based electrically conducting body electrically connected to the current injection circuit,
- at least one electrode held in free contact with a contact surface of the body; and
that this body comprises at least one trip zone adjacent to the electrode held in free contact and that upon injection of a sufficiently high current gas is evolved in the trip zone resulting in a essentially reversible change from low-resistivity state to high-resistivity state of the current limiting element.

5. A fault current limiter according to any of claims 3 or 4, **characterised** in that the current limiting element comprises;
- a non-tripping side where the contact surface is contacted with its corresponding electrode, and
- a tripping side where the contact surface is held in free contact with its corresponding electrode,
and that the energy development in the trip zone upon discharge of the capacitor will cause a gas evolution of the polymer-based material in the trip zone such that the electrode held in free contact is separated from the body on the trip side and the current in the main circuit is limited.

6. A fault current limiter according to claim 4 or 5, **characterised** in that the electrode on at least one side of the body (12) is divided and comprises at least one electrode for the main circuit (110) and at least one current injection electrode for the current injection circuit (111).

7. A fault current limiter according to claim 6, **characterised** in that the divided electrode is arranged on the non-tripping side of the current-limiting element.

8. A fault current limiter according to claim 6, **characterised** in that the divided electrode is supported by an electrically insulating and mechanically stiff supporting plate and that the supported divided electrode is held in free contact on a tripping side.

9. A fault current limiter according to any of claims 3, 4, 5, or 6 **characterised** in that the current limiting element comprises two or more electrically conducting bodies (120, 121) and electrodes; and

- that a first electrically conducting body (121) is polymer-based and arranged in the circuit for current injection (20);
- that a second electrically conductive body (120) with equal or lower resistivity than the first body is arranged in the main circuit (10).

10. A fault current limiter according to claim 9 **characterised** in that a common electrode (112) for both bodies (120, 121)and both circuits (10, 20) is arranged on one side of the bodies (120, 121) while a divided electrode is arranged on the other side.

11. A fault current limiter according to claim 9 **characterised** in that divided electrodes (110, 111, 115, 116) are arranged on both sides of the bodies (120, 121).

12. A fault current limiter according to claim 10 **characterised** in that the common electrode (112) is held in free contact on the tripping side of the current limiter.

13. A fault current limiter according to any of claims 10, 11 or 12 **characterised** in that at least one divided electrode is supported by an electrically insulating and mechanically stiff supporting plate and that the supported electrode is held in free contact with a contact surface on each body.

14. A fault current limiter according to any of the preceding claims, **characterised** in that electromechanical means are arranged electrically in series with a current injection circuit and that these electromechanical means are adopted to, upon discharge of the capacitor (21), generate a force counteracting the contact pressure applied by the pressure applying means.

15. A fault current limiter according to claim 14, **characterised** in that the electromechanical means are electrically connected to the current limiting element.

16. A fault current limiter according to claim 14, **characterised** in that the electromechanical means are electrically connected to a second circuit for current injection.

17. A fault current limiter according to any of the claims 1 or 2, **characterised** in that the current limiting device is a fuse.

18. A fault current limiter according to any of the claims 1 or 2, **characterised** in that the current limiting device is a resistor exhibiting a positive temperature coefficient and that the temperature of the resistor-body upon a sufficiently high current injection is raised above a temperature at which the resistor changes from its low-resistivity state to its high-resistivity state.

19. A fault current limiter according to any of the preceding claims, **characterised** in that a plurality of current limiting elements are connected in series to increase the voltage capability.

20. A fault current limiter according to any of claims 1 to 18, **characterised** in that a plurality of current limiting elements are connected in parallel to increase the rated current capability.

21. A fault current limiter according to claim 20, **characterised** in that a plurality of groups, comprising a plurality of current limiting elements connected in parallel, are connected in series to increase the rated current and the voltage capabilities.

22. A fault current limiter according to any of the claims 19, 20 or 21, **characterised** in that each current limiting element is electrically connected in parallel to one current injection circuit each to ensure that sufficient energy is injected in each current limiting element upon discharge of the capacitor to cause the current limiting element to trip.

23. A fault current limiter according to claim 22, **characterised** in that a plurality of current injection circuits are controlled by the same control unit.

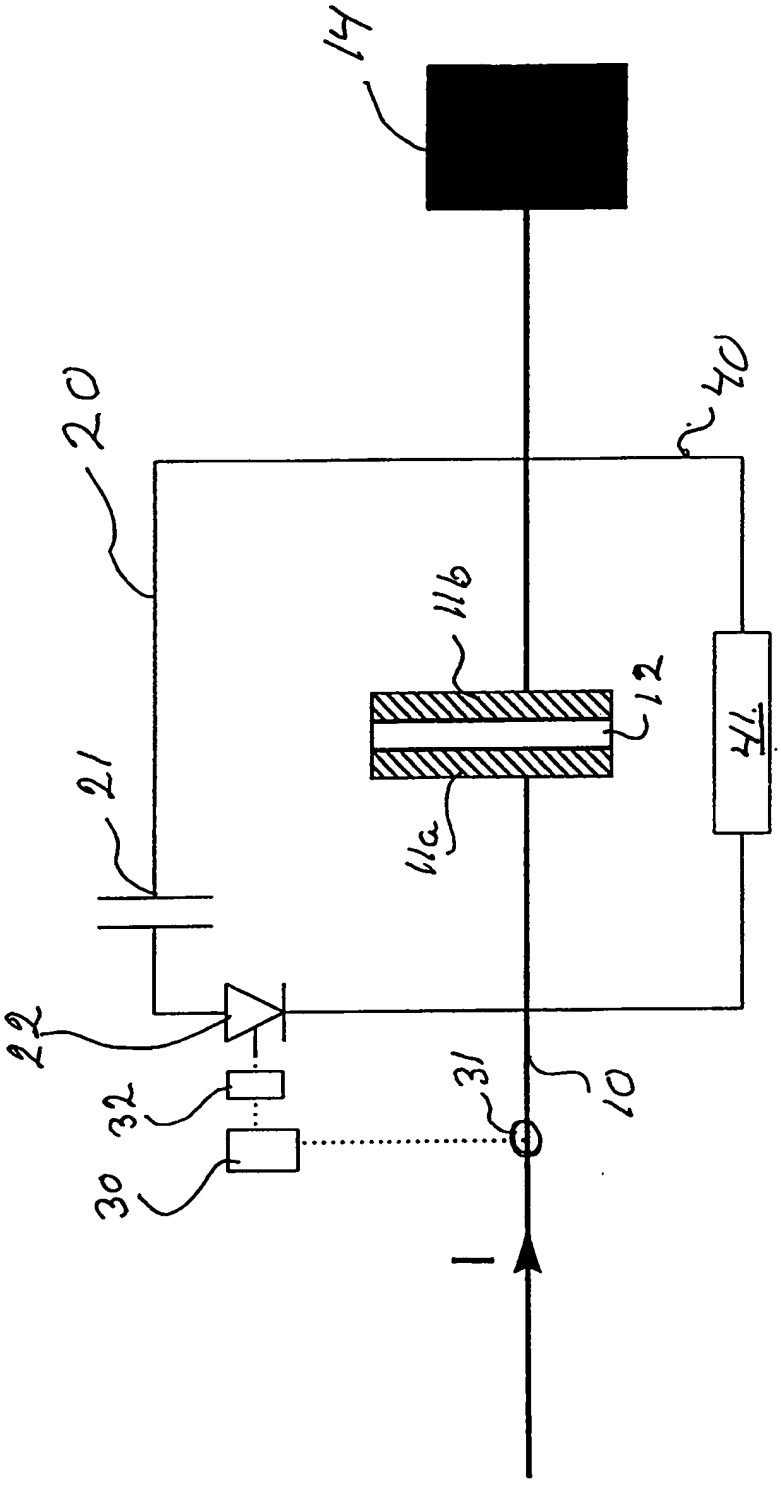

Fig. 1

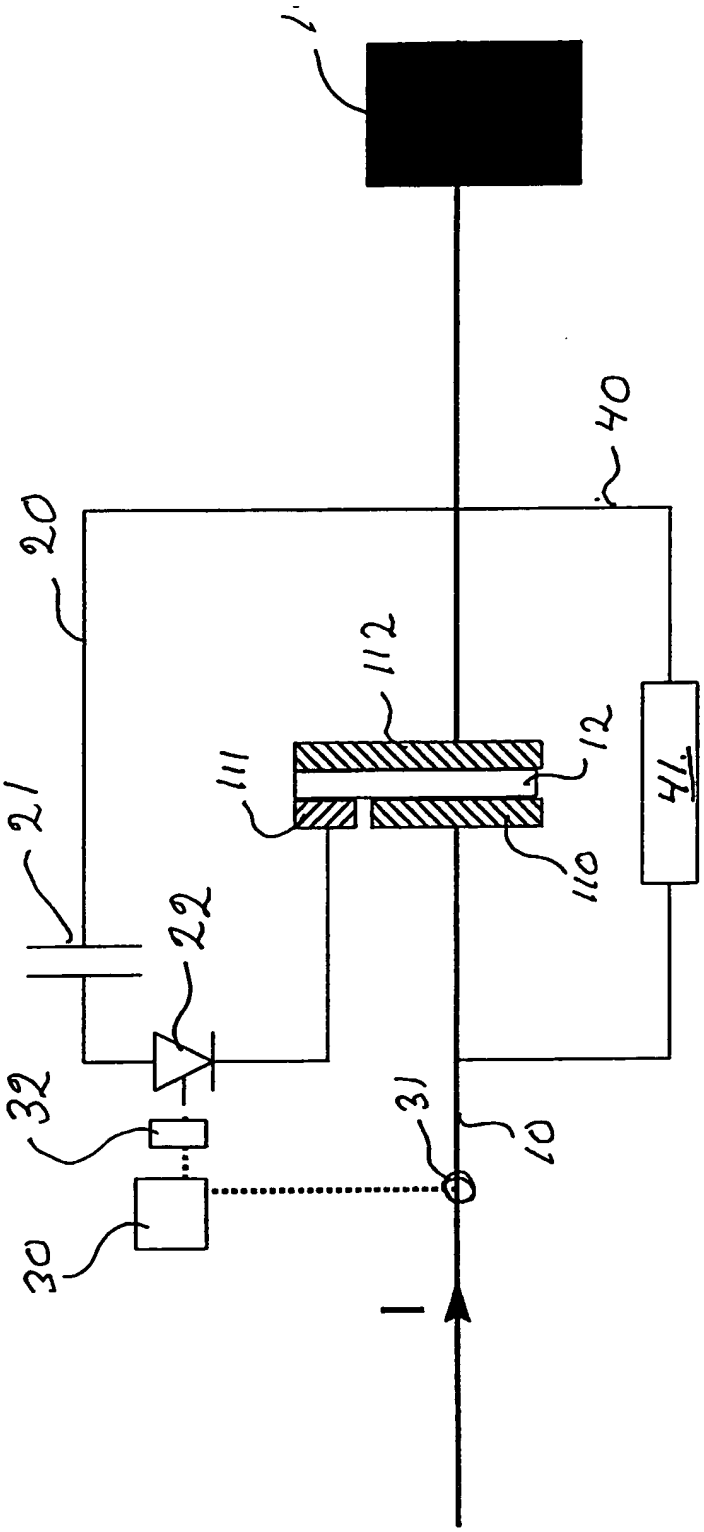

Fig.2

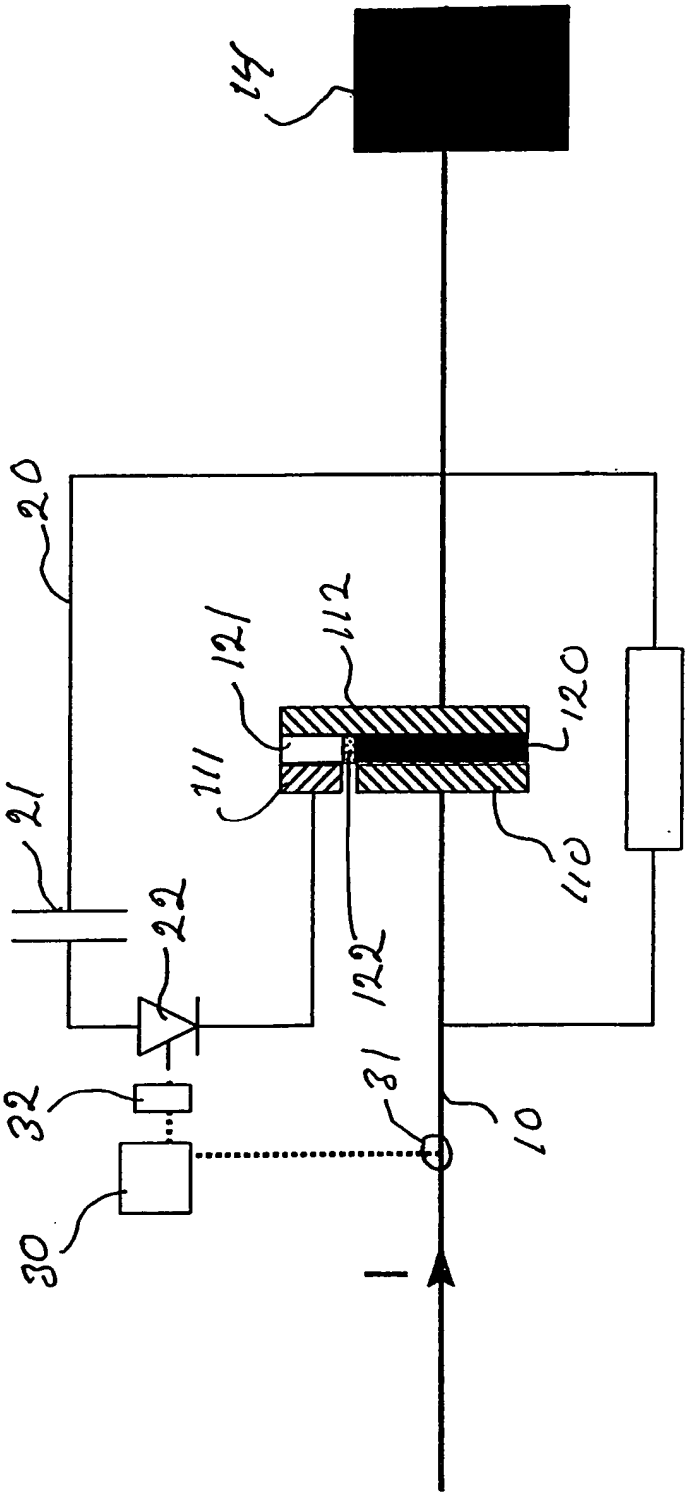

Fig.3

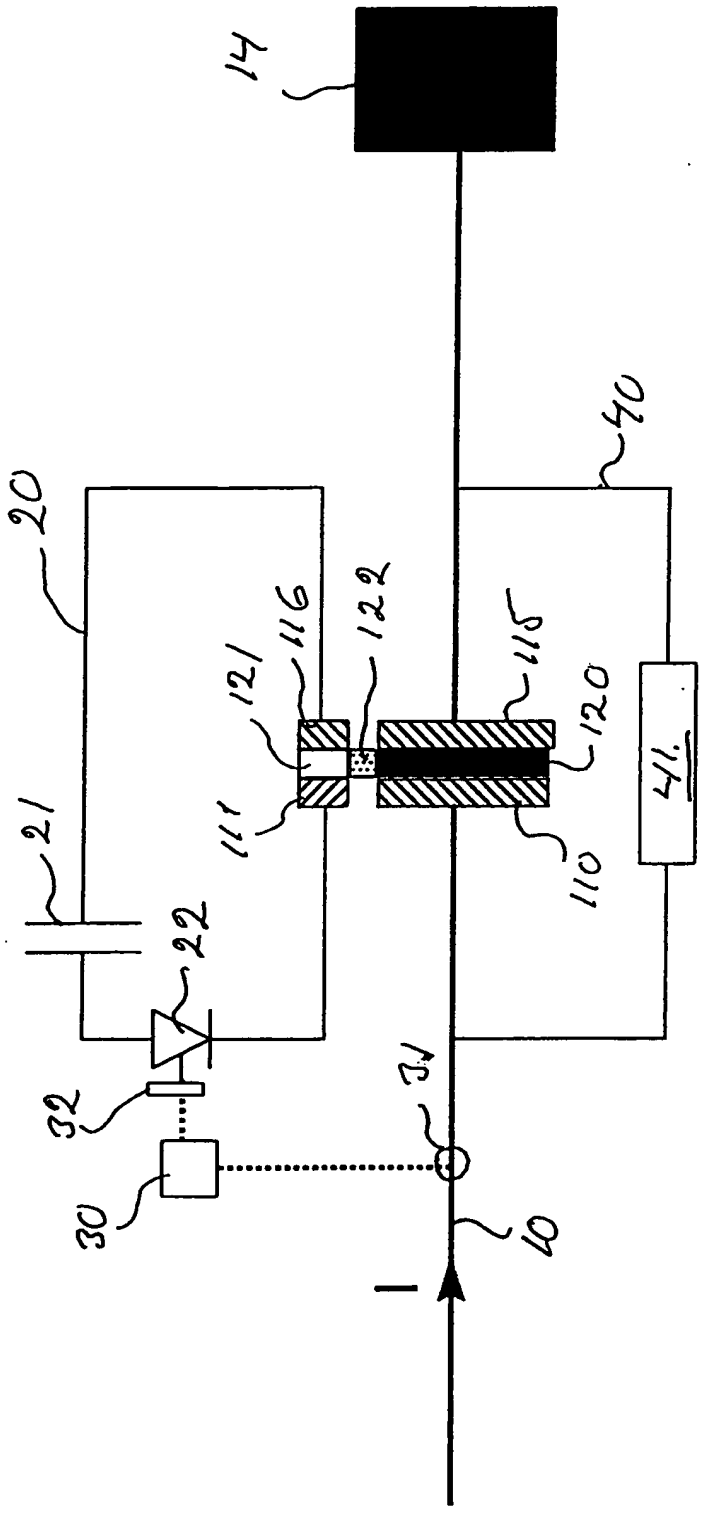

Fig. 4

INTERNATIONAL SEARCH REPORT

International application No.
PCT/SE 98/01135

A. CLASSIFICATION OF SUBJECT MATTER

IPC6: H02H 9/02
According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

IPC6: H01C, H02H

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

SE,DK,FI,NO classes as above

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

WPI

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US 5440441 A (OM AHUJA), 8 August 1995 (08.08.95), column 4, line 65 - column 9, line 50, figures 1-4	1,2,18-23
X	DE 1904244 A (FUJI ELECTRIC CO. LTD.), 6 August 1970 (06.08.70), page 8, line 31 - page 9, line 14, figure 10	1,2
Y		17
Y	SE 136731 C (W. MERGLER), 29 July 1952 (29.07.52), page 2, column 2, line 60 - page 3, column 1, line 12, figure 1	17

[X] Further documents are listed in the continuation of Box C. [X] See patent family annex.

* Special categories of cited documents:
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"O" document referring to an oral disclosure, use, exhibition or other means
"P" document published prior to the international filing date but later than the priority date claimed
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"X" document of particular relevance: the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone
"Y" document of particular relevance: the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art
"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
26 November 1998	01 -12- 1998
Name and mailing address of the ISA/ Swedish Patent Office Box 5055, S-102 42 STOCKHOLM Facsimile No. +46 8 666 02 86	Authorized officer Bertil Nordenberg Telephone No. +46 8 782 25 00

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INTERNATIONAL SEARCH REPORT

International application No.
PCT/SE 98/01135

C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
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A	DE 2060990 A (ALLMÄNNA SVENSKA ELEKTRISKA AB), 15 July 1971 (15.07.71), see the whole document	1,2
A,P	WO 9749156 A1 (LITTELFUSE, INC.), 24 December 1997 (24.12.97), see the whole document	1-23

INTERNATIONAL SEARCH REPORT

Information on patent family members

03/11/98

International application No.
PCT/SE 98/01135

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		WO 8602786 A	09/05/86
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